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### MALARIA AND THE CULTIVATION OF THE SOIL

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Malaria is often associated with the development of the resources of certain countries, and as it is at times particularly associated with the agricultural and rural development of a country, some considerations of the reasons for this relationship should be of interest to residents of Porto Rico.

To thoroughly understand the relationship, certain facts concerning malaria must first be considered. It is well known that there is only one way in which malaria is transmitted, that is, thru the bite of a mosquito which has at least ten days to two weeks previously become infected thru sucking blood from a person with malaria. The germ that causes malaria lives only in the blood and internal organs of human beings and within the body of the mosquito, and since the blood vessels naturally have no outlet, the only method of transmission from one person to another is by extraction of blood from an infected person and injection of the parasites directly into the blood of a healthy person. This transfer can be done experimentally with a syringe but in nature is only done by means of the mosquito. The ten days or two weeks between bites is necessary for the development of the parasite within the body of the mosquito whereby the union of a male and female parasite results in the production of a large number of very small active parasites. These travel to the biting organ of the mosquito to be ready to be injected into the blood of the person that is bitten.

It is also probably quite well known that there are numerous varieties of mosquitoes but that one variety only, the so-called Anopheles, is capable of transmitting the disease. The parasite is apparently unable to develop in the bodies of the other mosquitoes. As far as malaria is concerned, therefore, we are only interested in this one variety of mosquito and it is obvious that malaria can only exist to any extent where anopheles mosquitoes are found. Anything that tends to destroy these mosquitoes will also tend to exterminate malaria. Further, all mosquitoes develop from eggs to larvae, then pupae, and finally to the adult mosquito. The entire larval and pupal stages, lasting 8-10 days, are passed in water. Simply stated, without standing water there can not be adult mosquitoes, and without mosquitoes there cannot be malaria. But the anopheles mosquito does not develop in all places that water is found. In contrast to the ordinary house mosquito pest, the Stegomyia, the anopheles of Porto Rico do not develop to any great extent in artificial containers such as barrels, tin cans, cisterns, latrines, etc. Destruction of such water deposits will remove to a great extent the mosquito pest but not malaria. Anopheles seem to thrive best in open natural or artificial water courses which are more or less permanent, such as swamps, certain mangrove swamps, marsh lands, drainage and irrigation ditches with stagnant water, and in certain ponds and small lakes. Salt water is no hindrance and in fact at times it seems to favor breeding. Perfectly clean ditches with flowing water and no floating plants or algae do not breed mosquitoes in appreciable numbers nor do large bodies of water as rivers or lakes even with considerable vegetation if the wind produces many waves or if numerous small fish are present. It is noteworthy also that these mosquitoes can fly as far as a kilometer from their breeding grounds, when such flight is necessary to obtain food. With the above facts in mind we can easily understand why certain low wet lands are malarious.

In the development of the extensive tracts of farm lands in the central United States numerous such low places were encountered which were breeding these mosquitoes. As long as no one came into the region with malaria the mosquitoes did no harm, since the mosquitoes can only become infected by biting a person with the malarial parasites in the blood. As soon as a case of malaria was brought in from the outside, mosquitoes spread the disease to the rest of the people and indirectly caused a great deal of suffering and a large number of deaths. There are still numerous areas in the South and West of the United States which have not been developed because of mosquitoes and mala-



ria. Thus the natural conditions of the land with its swamps and small lakes and rivers were favorable for the development of the mosquitoes and the entrance of the people with malaria, into these areas produced conditions which favored the spread of the disease.

The tendency, however, is for malaria to naturally decrease as agricultural conditions are improved. The farmer, in order to grow better crops must drain off the excess water, and by so doing he unconsciously exterminates the mosquitoes and therefore the malaria. It has been known for a long time that drainage of swampy lands reduced malaria and also mosquitoes. It was not known that draining of marshes reduced malaria because of the extermination of the breeding places of the mosquitoes; however, until work of English and Italian investigations at the close of the nineteenth century proved that mosquitoes transmitted malaria. Thus it was that lands were drained to improve agricultural conditions and at the same time regions made more healthful. Some of the richest and healthiest places in the United States were previously poor and run down because of malaria.

But the development of new lands does not, unfortunately, always reduce or exterminate malaria and in fact may increase it. Certain crops can be grown as well or better in lands which are still wet or even flooded with water. Rice and sugar cane will grow under these conditions, and especially the former. In the case of the latter the ground in certain places is not drained thoroughly, land is thrown up into hills where the cane is planted and the water left in ditches in between where the anopheles mosquitoes breed. At other times due to lack of funds only parts of swamps are drained and, as the mosquitoes can fly considerable distances, the population which moves in to work the fields already drained soon becomes infected. If the tract of land is a large one a town may even be built on the edge of the part still undrained and with a concentration of population, the transmission of the disease is more easily and more rapidly accomplished. These are the conditions that we find when development does not proceed as it should and drainage is only half done.

In the development of other resources malaria may actually be produced in an area which otherwise would not have it. In hilly, wooded sections drainage is often good and there are no mosquitoes until dams are built to furnish power for various forms of mills or for electric plants, or irrigation. The artificial lakes formed produce anopheles mosquitoes, and the labor brings in the malarial parasites. Building of railroads often dam up small streams; and excavations for rocks or minerals leave holes in the ground which become filled with water and breed mosquitoes.

But the most important of so-called man-made malaria results from irrigation, that is, the bringing in of water where it was not present or was present in only small quantities previously. Theoretically, irrigation when properly done implies that the ditches shall have running water or shall be dry, and that the water shall stand about the plants irrigated only a short time. Under these conditions mosquitoes do not breed and there is no malaria. Unfortunately, irrigation systems often are not perfect and water stands in the ditches between irrigations. Vegetation and algae soon cover the edges of the ditches and ideal conditions are produced for anopheline breeding. The primary requirement for irrigation, namely good drainage, is not taken into consideration at times and water is poured on to fields without being properly taken off. Worse than that is the fact that the water may be drained from the actual field being irrigated but collected below in the lower lands not being cultivated. Existing water is thus increased and therefore the mosquitoes also. The amount of malaria which is actually made by man himself is surprisingly large.

The history of malaria in Porto Rico in the light of the above considerations is quite easily understood. In times past there were, probably, large numbers of anopheles mosquitoes but no malaria. Then some one entered the island with the malarial parasites in his blood and from then on mosquitoes became infected and the disease gradually spread throughout the island. It is now found as is well known, mainly in the coastal regions, for there is where large amounts of standing water are found. That malaria is still a serious problem is shown by the reports of the Department of Health, and by the results of special studies in Salinas, Guayama, Barceloneta, Manati, and Fajardo. Unfortunately for the public health, cane will grow in wet lands where water stands in between the rows of cane. Partial drainage has reduced the water sufficiently to grow some cane, and has reduced the mosquitoes, but the concentration of population near these situations to supply labor to work the lands has made transmis-



sion of the disease easier and fewer anopheles mosquitoes are needed. The work has only been half done in some parts, therefore, and, as in many other countries, reclaiming has only gone far enough to make a bare living and a dangerous one at that. With competition becoming keener, and sugar prices lower it will be necessary to grow more cane per acre. Evidence seems to show that removing of excess water alone will help to increase crops. This will help to remove malaria as well.

Undoubtedly malaria in Porto Rico is not as severe and abundant now as it was years ago and a great deal of credit must be given to those in the island who are responsible for the work already done. Lands formerly inhabitable have been reclaimed for agricultural purposes and where drainage has been good malaria exists only in small quantities. It is hoped that these same influences will continue and extend the work of efficient reclamation.

In many places, however, the work of reclamation has not been started and people have malaria without getting any crops from the water soaked soil. Reference is made particularly to the salt marshes of Porto Rico. In Bulletin No. 4 of the Experiment Station of the Sugar Producers' Association of Porto Rico, the subject of the Salt Marshes of the North Coast of Porto Rico is dealt with in detail by Dr. F. W. Zerban. Between Arecibo and Barceloneta alone lies a tract of land containing some 6000 acres which in the main can not be used for anything but pasture land and poor pasture at best, or a small yield of cane. The conclusions of the article indicated that proper drainage of the land, probably by means of dykes and pumps, would produce conditions very favorable for the production of cane. The adjacent region is a highly malarious one, as are many others in a similar condition. The main requirement for the conversion of these non-productive into productive lands is efficient drainage. This is the same requirement for the elimination of mosquitoes and malaria, and with a land shortage in Porto Rico there should be no delay in efficiently reclaiming not only the lands for crops but also the health of the people from the ravages of malaria. Reclaiming of lands pays, as has been proven in almost every country, but what is also being proven is that good health pays even higher dividends. But in the lands already under cultivation a danger has arisen - the main points of which have already been outlined.

In the cultivation of cane it appears that at times a stage is reached, especially when droughts are frequent, when the land becomes so dry that irrigation is needed. No one doubts that irrigation in many places is absolutely necessary but no one can deny that at times it is inefficiently done.

It is because of lack of attention to the proper care of irrigation ditches and to the removal of water that there are large numbers of anopheles mosquitoes and a large amount of malaria. Unfortunately for the health of the people cane will grow with an excess of water, but with the cost of living going up, more cane will have to be produced per acre and with a public becoming educated to the value of good health, conditions which undermine health will not be tolerated. It is not only necessary to make crops grow, but it is necessary to grow as much as possible and to go one step farther and closely follow the rule of "clean ditches and no stagnant water". The demand for irrigation is increasing; but further irrigation should be withheld until drainage systems are installed so that not only can the irrigation water be used to the greatest advantage but that the health of the people may be protected. Lands only partially reclaimed should be so completely reclaimed that the best crops are grown under the most healthful conditions.

Swampy lands are not only useless but are dangerous. By thorough drainage they can be made to pay big dividends, afford labor and space for an already crowded island, and the beautiful coast region with its many attractive beaches will be made healthful.

The actual working out of the problem is a difficult one and the greatest cooperation on the part of all concerned necessary. In general, where the matter has been brought to the attention of the property owners considerable interest and cooperation has been shown, but as the excess water on one's property often comes from the property adjacent it is clear that all must work together. In Barceloneta great advances have been made, for at one time the entire region was an impenetrable swamp. A considerable portion has been reclaimed and many are desirous of reclaiming the remainder. But one cannot build a dyke to keep the water from his neighbor's land, and since mosquitoes can fly long distances such a dyke would not keep the malaria off his lands. Since the poor and the middle classes as well as the property owners benefit from proper drainage of lands by improved health and therefore more working days, more pay, and more enjoyment out of life, and the property owners by increased crops, and the government by increased revenues, all need to contribute, to the end that the work may be carried forward successfully. Since a considerable portion of the lands are owned by the People of Porto Rico, it is possible that the Government might well make the first step. Provision could easily be made so that the worker himself might buy a small piece of the land later on which he might be educated to raise a few of the foods he needs. The least that should be done in situations where efficient drainage is slow and difficult of accomplishment is to prevent people from settling in the center of these mosquito infested regions and to remove those already there to the more healthy hill sections nearby.

